CLAIMS

What is claimed is:

1. An occlusion clip comprising:

an occlusion portion having

an upper single element occlusion member having proximal and distal upper member ends;

a lower single element occlusion member having proximal and distal lower member ends, the lower single element occlusion member and the upper single element occlusion member combining to define an occlusion member plane;

a spring portion having

a torsion spring connecting the proximal upper member end to the proximal lower member, the torsion spring having a spring height dimension in the occlusion member plane perpendicular to the upper and lower single occlusion members and being adapted to bias the upper and lower single element occlusion members toward a closed position wherein the upper single element occlusion member is in force contact with the lower single element occlusion member.

2. An occlusion clip according to claim 1 further comprising

a clip guide portion having

an upper clip guide attached to the distal end of the upper single occlusion member, the upper clip guide including a first planar member having a top upper guide surface and an engaging bottom upper guide surface, the first planar member being perpendicular to the occlusion member plane when the upper and lower single occlusion members are in engagement; and

a lower clip guide attached to the distal end of the lower single occlusion member, the lower clip guide including a second planar member

having a bottom lower guide surface and an engaging top lower guide surface, the second planar member being parallel to the first planar member when the upper and lower single occlusion members are in engagement.

3. An occlusion clip according to claim 1 wherein the spring height dimension increases as a rotational separation between the single element upper occlusion member and the single element lower occlusion member increases.

4. An occlusion clip according to claim 1 wherein the upper and lower single element occlusion members and the torsion spring are formed from a single continuous wire segment having first and second wire ends.

5. An occlusion clip according to claim 4 wherein the wire segment is formed from titanium and has a diameter in a range from about 10 mils to about 50 mils.

6. An occlusion clip according to claim 4 wherein the wire segment is formed from titanium and has a diameter in a range from about 20 mils to about 40 mils.

7. An occlusion clip according to claim 1 wherein the torsion spring biases the upper and lower single occlusion members to exert a maximum occluding force of at least 0.20 pounds.

8. An occlusion clip according to claim 1 wherein the occlusion portion has a maximum occlusion width dimension perpendicular to the occlusion member plane and the spring portion has a maximum spring width dimension perpendicular to the occlusion member plane, the maximum occlusion width dimension and the maximum spring width dimension each being in a range from about 10 mils to about 50 mils.

9. An occlusion clip according to claim 8 wherein the maximum occlusion width dimension and the maximum spring width dimension are each in a range from about 20 mils to about 40 mils.

10. An occlusion clip comprising:

an occlusion portion having

an upper single element occlusion member having proximal and distal upper member ends;

a lower single element occlusion member having proximal and distal lower member ends, the lower single element occlusion member and the upper single element occlusion member combining to define an occlusion member plane;

a spring portion having

a torsion spring connecting the proximal upper member end to the proximal lower member end, the torsion spring having a spring height dimension in the occlusion member plane perpendicular to the upper and lower single occlusion members and being adapted to bias the upper and lower single element occlusion members toward a closed position wherein the upper single element occlusion member is in force contact with the lower single element occlusion member

wherein the upper and lower single element occlusion members and the torsion spring are formed from a single continuous wire segment having a wire diameter and first and second wire ends, the occlusion portion having a maximum occlusion width dimension perpendicular to the occlusion member plane that is no greater than the wire diameter, and a maximum occlusion height dimension in the occlusion member plane that is no greater than twice the wire diameter.

11. An occlusion clip according to claim 10 wherein the wire segment is formed from titanium and has a diameter in a range from about 10 mils to about 40 mils.

12. An occlusion clip according to claim 10 wherein the wire segment is formed from titanium and has a diameter in a range from about 15 mils to about 30 mils.

13. An occlusion clip according to claim 10 wherein the torsion spring defines a maximum interior height dimension in the occlusion plane when the upper and lower single occlusion members are in engagement, the maximum interior height dimension being less than twice the wire diameter.

14. An occlusion clip according to claim 10 wherein the torsion spring biases the upper and lower single occlusion members to exert a maximum occluding force of at least 0.20 pounds.

15. An occlusion clip according to claim 10 further comprising

a clip guide portion having

an upper clip guide attached to the distal end of the upper single occlusion member, the upper clip guide including a first planar member having a top upper guide surface and an engaging bottom upper guide surface, the first planar member being perpendicular to the occlusion member plane when the upper and lower single occlusion members are in engagement; and

a lower clip guide attached to the distal end of the lower single occlusion member, the lower clip guide including a second planar member having a bottom lower guide surface and an engaging top lower guide surface, the second planar member being parallel to the first planar member when the upper and lower single occlusion members are in engagement.

16. A method of forming an occlusion clip from a single wire strand, the method comprising:

forming a torsion spring from a first portion of the wire strand;

forming a first occlusion member from a second portion of the wire strand, the first occlusion member having a proximal first member end connected to the torsion spring and a distal first member end;

forming a second occlusion member from a third portion of the wire strand, the second occlusion member having a proximal second member end connected to the torsion spring and a distal second member end, the first and second occlusion members defining an occlusion plane and having a closed configuration in which the first occlusion member is in contact with the second occlusion member and at least one open configuration in which the first and second occlusion members are rotated apart within the occlusion plane,

wherein the torsion spring applies a biasing force to bias the first and second occlusion members toward the closed configuration.

17. The method of claim 16 wherein the action of forming a torsion spring includes bending the first portion of the wire strand to form a loop.

18. The method of claim 16 wherein the wire strand is titanium.

19. The method of claim 16 further comprising:

distorting the combined first and second occlusion members and the torsion spring so that the first and second occlusion members are not coplanar;

rotating the first and second occlusion members toward and then past one another by a predetermined angular amount, thereby imparting a stress into the torsion spring and connections between the torsion spring and the occlusion members;

returning the first and second occlusion members to a coplanar condition so that the torsion spring biases the first and second occlusion members toward the closed configuration.

20. The method of claim 16 further comprising:

fixedly shaping the torsion spring into a teardrop shape.

21. The method of claim 16 wherein the wire strand is formed from a metal, the method further comprising:

heating the combined first and second occlusion members and the torsion spring to a temperature below the melting point of the metal for a predetermined time period.

22. The method of claim 21 wherein the metal is titanium.

23. The method of claim 21 wherein the combined first and second occlusion members and the torsion spring are heated to a temperature is in range of about 600 to about 1600 degrees Fahrenheit.

24. The method of claim 21 wherein the combined first and second occlusion members and the torsion spring are heated to a temperature is in range of about 1100 to about 1300 degrees Fahrenheit.

25. The method of claim 21 wherein the action of heating the combined first and second occlusion members is carried out in a vacuum environment.

26. The method of claim 21 wherein the action of heating the combined first and second occlusion members is carried out in an inert gas environment.

27. The method of claim 21 wherein the action of heating the combined first and second occlusion members is carried out in an oxygen environment.

28. A method of removing an occlusion clip from a tissue to which the occlusion clip is applied, the occlusion clip having upper and lower single element occlusion members connected by a torsion spring having an outside spring surface and an inside spring surface surrounding a spring opening having an effective spring diameter, wherein the torsion spring biases the upper and lower single element occlusion members toward a closed position in which the upper single element occlusion member is in contact with the lower single element occlusion member occluding tissue and wherein increasing the effective spring diameter of the torsion spring causes the upper and lower single

element occlusion members to separate, the tissue being disposed between and engaged by the upper and lower single occlusion members, the method comprising:

inserting a tapered element into the spring opening and into contact with the inside spring surface;

applying a spreading force to the inside spring surface, thereby causing the effective spring diameter to increase thereby causing the upper and lower single element occlusion members to separate and disengage from the tissue; and

removing the occlusion clip from the tissue.

29. The method of claim 28 wherein the tapered element comprises a leg mounted to a pushing surface, the leg being tapered to a larger dimension toward the pushing surface to which it is mounted such that it will spread occlusion members as it is pushed further into and through the spring opening.

30. The method of claim 28 wherein the inside spring surface is teardrop shaped.

31. An occlusion clip applicator for storing and applying a plurality of occlusion clips each having an occlusion portion with an upper single element occlusion member having proximal and distal upper member ends and a lower single element occlusion member having proximal and distal lower member ends, the lower single element occlusion member and the upper single element occlusion member combining to define an occlusion member plane and having a maximum occlusion member width dimension perpendicular to the occlusion member plane, a spring portion having a torsion spring connecting the proximal upper member end to the proximal lower member, the torsion spring having a spring height dimension in the occlusion member plane perpendicular to the upper and lower single occlusion members and being adapted to bias the upper and lower single element occlusion members toward a closed position wherein the upper single element occlusion member is in force contact with the lower single element occlusion member, and a clip guide portion having an upper clip guide attached to the

distal end of the upper single occlusion member and a lower clip guide attached to the distal end of the lower single occlusion member, the upper and lower clip guides having a maximum clip guide width, the applicator comprising:

a jaw actuator tube having proximal and distal actuator tube ends and a jaw actuator tube interior;

an elongate clip holder configured to hold the plurality of occlusion clips, the clip holder being formed as a U-shaped channel with a channel interior, proximal and distal clip holder ends and first and second support rails disposed within the channel interior, the first and second support rails being substantially parallel and coplanar and defining a rail gap with a rail gap width dimension that is nominally greater than the maximum occlusion member width dimension and less than the maximum clip guide width, at least a portion of the channel being disposed within the jaw actuator tube interior;

a clip pusher having an elongate support member with a plurality of clip push fingers attached to the support member, the support member being mounted such that at least a portion of each clip push finger extends into the channel interior; and

a pair of jaws, each jaw having proximal and distal jaw ends, an inner engaging side and an opposite outer side, a clip slot formed through the jaw from the inner engaging side to the outer side and extending distally from and through the proximal jaw end, and a pair of parallel support shelves bounding at least a portion of the clip slot, the jaws being pivotably mounted at their proximal ends to the distal clip holder end and being configured for engagement by the distal tube end for selective rotation between a fully open position and a closed position wherein the engaging sides of the jaws are in contact with each other, wherein the clip slot has a width dimension that is nominally greater than the maximum occlusion member width dimension and less than the maximum clip guide width.

32. An occlusion clip applicator according to claim 31 wherein the clip slot terminates in an ejection opening adjacent the distal jaw end, the ejection opening having an ejection opening width that is greater than the maximum clip guide width.

33. An occlusion clip applicator according to claim 31 wherein the jaws each have a pair of ramps bounding a proximal portion of the clip slot, the ramps being aligned with the support shelves and the support rails of the clip holder.

34. An occlusion clip applicator according to Claim 31 wherein the jaws each comprise maximum open construction for viewing the occlusion clip throughout an installation process.

35. An occlusion clip applicator according to claim 31 wherein the clip push fingers each terminate in a clip push foot configured for engagement with the upper clip guide of each occlusion clip so that distal movement of the clip pusher causes the occlusion clips to slide distally along the support rails.

36. An occlusion clip applicator according to claim 31 further comprising:

means for selectively moving the jaw push tube in a distal direction to engage the jaws and cause them to rotate from the open position to the closed position; and

means for selectively moving the clip pusher in the distal direction to cause distal movement of at least one occlusion clip disposed in the clip holder.

37. An occlusion clip applicator according to claim 36 wherein the means for selectively moving the jaw push tube and the means for selectively moving the clip pusher are adapted for moving the jaw push tube and the clip pusher in a predetermined sequence initiated by a user.

38. An occlusion clip applicator according to claim 31 further comprising:

a tube actuator operatively associated with the jaw push tube and the clip pusher and configured to produce selective distal and proximal movement of the jaw push tube and the clip pusher relative to the clip holder.

39. An occlusion clip applicator according to claim 38 wherein the actuator is adapted to produce the distal movement of the jaw push tube and the clip pusher in a predetermined sequence initiated by a user.

40. An occlusion clip applicator according to claim 38 further comprising:

a rotator attached to the proximal push tube end, the rotator having a rotator interior in which the proximal clip holder end and at least a portion of the tube actuator are disposed.

41. An occlusion clip applicator according to claim 40 further comprising:

a handle assembly attached to the rotator, the handle assembly having a handgrip with a handgrip interior space and a trigger rotatably mounted to the handgrip, the trigger being operatively associated with the tube actuator for selective activation thereof.

42. An occlusion clip applicator for storing and applying a plurality of occlusion clips comprising:

a jaw push tube having proximal and distal push tube ends and a jaw push tube interior;

an elongate clip holder having proximal and distal clip holder ends, the proximal end of which is fixedly attached to a barrel housing, the clip holder being configured to hold the plurality of occlusion clips and being formed as a U-shaped channel with a channel interior, proximal and distal clip holder ends and first and second support rails disposed within the channel interior, the first and second support rails being substantially parallel and coplanar and

defining a rail gap with a rail gap width dimension, at least a portion of the channel being disposed within the jaw actuator tube interior;

a clip pusher having an elongate support member having upper and lower sides with a plurality of clip push fingers attached to the lower side, the support member being mounted within the jaw push tube interior substantially parallel to the clip holder with at least a portion of each clip push finger extending downward into the channel interior; and

a pair of jaws, each jaw having proximal and distal jaw ends, an inner engaging side and an opposite outer side, a clip slot formed through the jaw from the inner engaging side to the outer side and extending distally from and through the proximal jaw end, and a pair of parallel support shelves bounding at least a portion of the clip slot, the jaws being pivotably mounted at their proximal ends to the distal clip holder end and being configured for engagement by the distal tube end for selective rotation between a fully open position and a closed position wherein the engaging sides of the jaws are in contact with each other.

43. An occlusion clip applicator according to claim 42 wherein the clip slot terminates in an ejection opening adjacent the distal jaw end, the clip slot having a slot width and the ejection opening having an ejection opening width that is greater than the slot width.

44. An occlusion clip applicator according to claim 43 wherein the jaws each have a pair of ramps bounding a proximal portion of the clip slot, the ramps being aligned with the support shelves and the support rails of the clip holder.

45. An occlusion clip applicator according to Claim 42 wherein the jaws each comprise maximum open construction for viewing the occlusion clip throughout an installation process.

46. An occlusion clip applicator according to claim 42 wherein the gap width dimension is sized so that the occlusion clips each have a first clip portion that is

narrower than the rail gap and a second clip portion that is wider than the rail gap thus allowing the clips to be slidably disposed in the clip holder with minimal lateral movement with the second clip portion of each clip engaging the support rails.

47. An occlusion clip applicator according to claim 46 wherein the clip push fingers each terminate in a clip push foot configured for engagement with a third clip portion so that distal movement of the clip pusher causes the occlusion clips to slide distally along the support rails.

48. An occlusion clip applicator according to claim 42 further comprising:

means for selectively moving the jaw push tube in a distal direction to engage the jaws and cause them to rotate from the open position to the closed position; and

means for selectively moving the clip pusher in the distal direction to cause distal movement of at least one occlusion clip disposed in the clip holder.

49. An occlusion clip applicator according to claim 48 wherein the means for selectively moving the jaw push tube and the means for selectively moving the clip pusher are adapted for moving the jaw push tube and the clip pusher in a predetermined sequence initiated by a user.

50. An occlusion clip applicator according to claim 42 further comprising:

an actuator operatively associated with the jaw push tube and the clip pusher and configured to produce selective distal and proximal movement of the jaw push tube and the clip pusher relative to the clip holder.

51. An occlusion clip applicator according to claim 50 wherein the actuator is adapted to produce the distal movement of the jaw push tube and the clip pusher in a predetermined sequence initiated by a user.

52. An occlusion clip applicator according to claim 50 wherein the barrel housing defines a barrel chamber and the proximal push tube end, the proximal clip holder end and at least a portion of the actuator are disposed in the barrel chamber.

53. An occlusion clip applicator according to claim 52 further comprising:

a handle assembly attached to the barrel housing, the handle assembly having a handgrip with a handgrip interior space and a trigger rotatably mounted to the handgrip, the trigger being operatively associated with the tube actuator for selective activation thereof.

54. A method of applying an occlusion clip employing an occlusion clip applicator comprising a handle, a trigger, a reciprocating jaw actuator, a reciprocating clip pusher having a distal and a proximal position and fingers engaging an upper clip guide, an occlusion clip holder, a stack of occlusion clips disposed in the occlusion clip holder, each clip having a torsion spring section, an occlusion section, and a clip guide section, a clip follower, upper and lower rotatable jaws having an open and a closed position, each jaw having an open clip track and an ejection element, the method comprising:

placing the open jaws around a tissue structure;

activating the trigger to

initiate movement of the jaw actuator from a proximal to a distal position thereby rotating the jaws toward the closed position,

move the clip pusher from a proximal pusher position to a distal pusher position,

engage the proximal most finger into the clip follower,

push the clip stack distally, each clip pushing on the proximal end of the next distal-most clip, the follower pushing on the proximal end of the proximal-most clip,

move the distal-most occlusion clip onto the jaws with the upper clip guide engaged onto the upper jaw open clip track and the lower clip guide engaged onto the lower jaw open clip track,

eject the distal-most occlusion clip through the ejection elements, and occlude the tissue by the distal-most occlusion clip.

55. The method of claim 54 wherein the follower is constructed of metal or plastic.

56. The method of claim 54 wherein the follower comprises a barrier that blocks the entrance of the follower into the jaws.

57. The method of claim 54 further comprising:

releasing the trigger which results in

movement of the jaw actuator from the distal position to the proximal position thereby rotating of the jaws to the open position,

movement of the clip pusher from the distal pusher position to the proximal pusher position, movement of the clip pusher perpendicular to the proximal-distal movement being minimized by a bias force so that the fingers clear the clips guide section without having to move enough to clear the spring bias section.

58. The method of claim 57 wherein the clip pusher comprises lateral fingers to engage the clip guide section and is U shaped to clear the spring bias.

59. The method of claim 58 wherein the clip guide section on the occlusion clips comprises an upper and lower clip guide each guide having a thickness with the clip pusher engaged with the upper clip guide of a clip in the stack prior to reset and rides upwards over the thickness of the upper clip guide of the clip just proximal during the reset.